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Publications:

Development and application of Danish Key Performance Indicators for Railway Timetables

Company managers want to be able to measure and evaluate the processes taking place in their companies to evaluate performance levels. This is also the case for the railway sector. Politicians demand a higher efficiency from infrastructure managers (IM) and train operating companies (TOC) by requiring improved products with reduced costs at the same time. Introducing Key Performance Indicators (KPI) can help achieve a higher efficiency. Creation of a feasible and attractive railway timetable is the most important process for both TOC and IM. When measuring the quality of the produced timetables, one also measures the success of the applied timetabling process.

KPI for railway timetables must be based on a common accepted set of timetabling criteria. This paper begins with a brief description of the process that lead to the creation of a common Danish list of prioritized timetabling evaluation and optimization criteria. It included individual interviews and a joined timetabling criteria workshop with the most important stakeholders. See below for the result:

* High prioritization: Consumption of capacity on railway line sections & Systematic timetables are preferable

* Medium prioritization: Robustness of the timetable & Societal acceptance of the timetable

* Low prioritization: Travel time of trains & Attractive train transfer options

General information

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Organisations: Department of Transport, Traffic modelling and planning

Authors: Schittenhelm, B. (Intern), Landex, A. (Intern)

Keywords: (timetable evaluation, railway timetables, timetable optimization, key performance indicators)

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Quantitative Methods for Assessment of Railway Timetables

The aim of this PhD thesis is to improve the attractiveness of future railway timetables. To achieve this goal, the qualitative term "timetable attractiveness" needs to be made quantifiable. To establish what timetable attractiveness is, the thesis gives an introduction to railway timetables in the form of a timetable definition and an overview of commonly used timetable types and existing timetable classes. All major timetable stakeholders in a given railway sector must agree on the timetable aspects covered by the term "timetable attractiveness". This research succeeded in creating such an agreement in the Danish railway sector, through a process that included individual stakeholder interviews followed by a joint timetabling criteria workshop. The agreement is a list of six prioritized timetable evaluation and optimization criteria. To make the evaluation criteria quantifiable, a set of key performance indicators (KPIs) was developed for each criterion. A total of 13 KPIs are presented. Their practical applicability has been successfully tested on examples of real-life Danish timetables. The thesis recommends a revised timetabling process at railway infrastructure manager Rail Net Denmark (in Danish:

Banedanmark) that will take the recommended KPIs into consideration. This new time-tabling process will create the necessary foundation for improving future railway timetable attractiveness in Denmark. The aim and the structure of this PhD thesis are described in Chapter 1. The thesis shows how railway traffic and the railway timetable have been interlocked almost from the opening of the first public railway line in 1825. A timetable increases both the traffic safety and the attractiveness of railways. Timetables plan traffic, avoid train collisions, and announce train services to potential customers. Chapter 2 gives an introduction to railway timetables. The thesis identifies a need for an improved European definition of a railway timetable. A two-part definition is introduced, with one part covering a liberalized railway sector and the other covering a state-owned or completely privately owned railway monopoly. The former is an agreement between an infrastructure manager and one or more train operating companies. The latter is an internal company agreement. This is followed by the presentation of some basic facts that apply to all railway timetables. A railway timetable has a time period of validity. In the European Union this has been harmonized to one year and the timetable changes take place on the Sunday following the second Saturday in December. The thesis distinguishes between timetables created as part of long or short-term planning. A short-term timetable tries to make the best of the available resources, such as railway infrastructure and rolling stock fleets, to accommodate as many railway customer preferences as possible. When preparing a long-term timetable, the starting point is to create an ideal timetable that fulfils the customer preferences on the assumption that the necessary infrastructure and rolling stock can be made available. Moreover, the thesis identifies eight basic line structures for train services found in a railway timetable. These basic train service line structures are: 1. Point-to-point line (high speed trains) 2. Circle line (suburban trains or metro) 3. Centralized nodes (e.g. Paris or London) 4. Corridor / tree structure (e.g. the Danish railway network) 5. Star shape (e.g. the metro in Rome) 6. Universal star shape (e.g. the metro in Athens) 7. Railway network with a core route (suburban trains in Copenhagen and Munich) 8. Meshed railway network (German InterCity-Express trains). Chapter 3 gives an overview of the six most commonly used timetable types in the railway sector. These timetable types are: 1. The public timetable (available to everybody, on paper and/or digitally) 2. The working timetable (primarily used by train staff) 3. The graphical timetable or train graph (used by timetable planners and traffic dispatchers) 4. The track occupation diagram (used by timetable planners and traffic dispatchers) 5. Rolling stock roster plan (used by employees of the train operating companies) 6. Train staff roster plan (used by employees of the train operating companies). The thesis identifies seven existing basic railway timetable classes. At the beginning of Chapter 4, an extended timetable categorization model is presented. The categorization of timetables into classes is based on the level of structure in a given timetable. A set of basic structural characteristics determine the level of structure. These structural characteristics are: x Timetable periodicity (the timetable is systematic (repeating traffic patterns)) x Timetable symmetry (same stopping pattern and travel times for both driving directions of a train service) x Train meetings at selected station hubs (optimal transfer options) x High frequency train services (train services run at least every 10 minutes) The seven basic timetable classes identified by this thesis are: x The periodic / systematic timetable - The symmetric periodic / systematic timetable - The integrated fixed interval timetable (IFIT) x The high frequency timetable - The non-periodic / non-systematic timetable - The symmetric non-periodic / non-systematic timetable - The integrated non-periodic / non-systematic timetable Based on earlier British and Swiss approaches to measuring the level of structure in a railway timetable, the thesis proposes improvements to these existing methods and introduces two new timetable structure indexes based on the newly developed concept of timetable patterns. The two indexes are: x Systematic timetable index – using the most used timetable pattern timewise x Systematic timetable index – using the longest continuous timetable pattern timewise Finally, the seven timetable classes are described and compared in detail with each other. This gives an overview of strengths and weaknesses based on selected, but generally accepted, timetable evaluation criteria. Identifying the basic railway timetable classes in a timetable that covers an entire network is difficult and labour-intensive work. Chapter 5 presents a series of examples of timetable analyses to illustrate the VI Summary complexity of the task. It starts with the example of one railway line section served by one train service running according to one timetable class; goes on to the more complicated example of one railway line section served by several train services with different timetable classes, and ends with the most complicated example of an entire railway network served by several timetable classes. The thesis recommends weighting the timetable classes identified with timetable statistical factors such as: the number of train runs, passenger numbers, freight tons, train-kilometres, and passenger or freight ton-kilometres. Chapter 6 starts with a brief historical overview of the liberalization process in the European railway sector and of the liberalization of the Danish railway sector in particular. This is followed by a presentation of the overall Danish railway timetabling process. The process is one of collaboration between the infrastructure manager Rail Net Denmark (in Danish: Banedanmark), the train operating companies, and the Danish Transport Authority (in Danish: Trafikstyrelsen), which is the buyer of public railway service traffic. Next comes a detailed description of the timetabling processes at the following railway timetable stakeholders: x The Danish Transport Authority – buyer of public railway service traffic x The train operating company DSB – the largest passenger train operator x The state-owned infrastructure manager Rail Net Denmark – prepares the annual timetable There is no formal timetabling process at the Danish Transport Authority. It changes from project to project. Since Rail Net Denmark is a member of the professional body of European infrastructure managers, Rail Net Europe, the basic timetable process steps and their deadlines are already given for the annual national timetable. Surprisingly, the basic Rail Net Europe timetabling process has no built-in formal learning loop. Both DSB and Rail Net Denmark have informal learning loops in their existing timetabling processes, in the form of experience based input from employees at the beginning (Rail Net Denmark) and/or evaluation of the proposed timetable before the final approval (DSB and Rail Net Denmark). The research for this thesis initiated a process to reach a consensus on timetable attractiveness in the form of timetable evaluation and optimization criteria in the Danish railway sector for the first time ever. Chapter 7 describes the process in detail. First, the most important railway timetable stakeholders were identified. They are: x DSB – the biggest Danish passenger train operating company x Arriva Danmark – the winner of the first public passenger traffic tender in Denmark x DB Schenker Rail Scandinavia – the biggest freight train operating company x The Danish Transport Authority – the buyer of public railway service traffic x Rail Net Denmark – the state-owned infrastructure manager The process started with an individual interview with each stakeholder to establish

a prioritized list of the five most important timetable evaluation criteria in the opinion of the interviewee. This was followed by a joint timetabling criteria workshop based on the five lists of prioritized criteria from the interviews. Arriva Danmark was not able to participate in the workshop. The participants of the workshop reduced the number of timetable evaluation criteria to six on their own initiative through discussion and dialogue. To achieve an individual ranking of the six criteria, each stakeholder was given three votes and was asked to give three different criteria one vote each. The result of the voting was three layers of priority with two criteria in each layer:

- High priority (3 votes): Systematic timetables and Capacity consumption on railway line sections
- Medium priority (2 votes): Robustness of the timetable and Societal acceptance of the timetable
- Low priority (1 vote): Attractive transfer options and Travel times

The workshop was unable to achieve consensus on an individual ranking of the six selected timetable evaluation and optimization criteria, so this is the result of the process initiated and conducted in the research for the thesis. It is the first version of a common list of prioritized railway timetable evaluation and optimization criteria in Denmark. Since the Danish railway sector is highly affected by the ever-changing national political climate, this list is not necessarily very stable. The thesis therefore recommends that a similar (and perhaps improved) process should be carried out every two to five years to ensure an up-to-date common understanding of timetable attractiveness in the Danish railway sector. A lack of focus on customer preferences was also identified through the results of the stakeholder interviews and the workshop. None of the parties set aside enough resources to perform large analyses within this important subject. Chapter 8 analyses each criterion from the common Danish list of prioritized railway timetable evaluation and optimization criteria with regard to the most important influencing factors. This includes the societal aspect in the form of political decision makers and railway customers. Technical aspects are covered in the form of railway train operating companies and infrastructure managers. The most important influencing factors are shown to be "Political requirements", "Customer requirements", "Train operating company requirements" and "Infrastructure characteristics". This thesis recommends eight new steps of analysis in a future timetabling process to ensure an improved risk and attractiveness evaluation of a timetable. It also presents a proposal for a revised timetabling process at railway infrastructure manager Rail Net Denmark. The basic working steps remain the same, since they are given by European Union legislation and Rail Net Europe guidelines. The important changes are that timetable planners will work with several timetable variants simultaneously and that a real iterative capacity allocation process with the train operating companies will take place. This will require a much more intelligent and efficient timetable planning system than is available today. A set of 13 key performance indicators for the Danish railway system is presented in Chapter 9. Seven of these are newly developed. Each key performance indicator is connected to one of the six timetable evaluation criteria. The key performance indicators are:

1. Systematic timetable index (Systematic timetable)- Based on the total time of the most used timetable pattern
2. UIC 406 methodology (Capacity consumption on railway line sections)
3. Degree of deviation from timetable planning rules (Robustness of the timetable)- Focus on agreed upon running times and timetable supplements
4. Conflict Risk Index (Robustness of the timetable)- The number of potential train path conflicts at a station and their estimated risk level
5. Timetable train path fix points (Robustness of the timetable)- Geographical and temporal distribution of potential train path conflicts
6. Proportion of train paths with shared rolling stock (Robustness of the timetable)- Number of train paths with shared rolling stock compared to the total number
7. Proportion of train paths with shared train staff (Robustness of the timetable)- Number of train paths with shared train staff compared to the total number
8. Proportion of buffer time in turnaround time and hand-over time for rolling stock (Robustness of the timetable)- Level of time supplements at terminus stations for rolling stock until next departure
9. Proportion of buffer time in turnaround time and hand-over time for train staff (Robustness of the timetable)- Level of time supplements at terminus station for train staff until next departure
10. Independent organization carrying out customer satisfaction surveys (Societal acceptance of the timetable)- Inspired by the British organization "Passenger Focus"
11. Proportion of timetable transfer time prolongation (Attractive transfer options)- Timetabled extra transfer time compared to physical minimum possible transfer time
12. Proportion of optimal transfer conditions (Attractive transfer options)- Number of transfers planned to take place on the same platform out of the total number
13. Proportion of timetable travel time prolongation (Travel time)- Timetabled extra travel time compared to travel time for theoretical non-stop train

These key performance indicators have proven themselves in practical applications on examples of real-life Danish timetables. All calculations were done manually, but they could be automated and integrated into future versions of timetabling software packages.

General information

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Authors: Schittenhelm, B. H. (Intern), Nielsen, O. A. (Intern), Landex, A. (Intern)

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Creating a common Danish list of railway timetable evaluation criteria and revising the timetabling process accordingly

With the liberalization of the European railway sector, the number of national railway timetable stakeholders has increased drastically. A need arises for reaching a common consensus about the timetabling criteria and their priority which the timetabling process should be based on.

To create a common Danish list of railway timetable evaluation and optimization criteria a two step process was launched. Individual interviews were conducted with selected Danish stakeholders: DSB, Arriva, DB Schenker Rail, The Danish Transport Authority and Rail Net Denmark. Each stakeholder made a list of five prioritized timetabling criteria. These lists were input for the second working step: A timetabling criteria workshop at the Technical University of Denmark, where a first agreement on timetabling criteria between stakeholders was achieved. The result was a three layered list of prioritized criteria. Rank 1 criteria: capacity consumption on line sections and systematic timetable. Rank 2 criteria: robustness of the timetable and societal acceptance of the timetable and rank 3 criteria: travel time of trains and attractive transfer options.

With this new tool a revised timetabling process at Rail Net Denmark is proposed. The very basic structure of the process cannot be changed due to EU legislation and Rail Net Europe guidelines. Key performance indicators derived from the identified timetabling criteria are introduced. As is a more iterative approach to the timetabling process due to the assumption of major improvements within timetable planning systems. This new iterative timetabling process using key performance indicators will result in improved future timetables and in lower levels of disagreement between timetable stakeholders.

General information

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Authors: Schittenhelm, B. (Intern), Landex, A. (Intern)

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Computation of a Suburban Night Train Timetable Based on Key Performance Indicators

Timetable evaluation can be based on a set of key performance indicators. This article presents six essential key performance indicators: Fixed interval service frequency, direct connections, transfer waiting time, use of dedicated rolling stock, dedicated train personnel, dedicated tracks and travel time. A short description and specific calculation method is given for each of these. The article recommends three different approaches for dividing the railway network into sections of analysis in regards to the key performance indicators. Three timetable variants for suburban night trains in Copenhagen are evaluated. Each timetable variant was created with a different performance focus. Values for each of the six key performance indicators are calculated and an average value is found for all timetable variants. It can be concluded that the actual implemented timetable receives the highest scores, but a clear picture of which timetable variant is best is not achieved. To get a clearer picture the introduction of weights is recommended both for the indicators as a whole and in the specific calculation methods. A prioritization of the selected key performance indicators is essential and weights in form of e.g. passenger numbers are needed in the specific calculations.

General information

State: Published

Organisations: Traffic Modelling, Department of Transport

Authors: Schittenhelm, B. (Intern), Landex, A. (Intern)

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Source: orbit

Source-ID: 266523

Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Quantitative Methods to Evaluate Timetable Attractiveness

The article describes how the attractiveness of timetables can be evaluated quantitatively to ensure a consistent evaluation of timetables. Since the different key stakeholders (infrastructure manager, train operating company, customers, and society) have different opinions on what an attractive timetable is, the article categorizes the different interests for each key stakeholder. Based on this categorization, the most important timetable attractiveness parameters are described (timetable structure, timetable complexity, travel time, transfers, punctuality and reliability). The descriptions of the timetable attractiveness parameters form the basis for proposing preliminary attractiveness indexes that are assigned an index value. In the end all the attractiveness indexes are collected and one overall preliminary attractiveness index is proposed. Although one (preliminary) attractiveness index is proposed it is still necessary to keep the individual attractiveness parameters to be able to analyse where it is possible to improve the timetable – and possibly the infrastructure too. Since the indexes are preliminary proposals they can each be improved and thereby also improving the overall timetable attractiveness index. To identify the preferred timetable structure it could e.g. be useful to apply multi criteria analysis methodology to weight the input from the stakeholders. A route choice model could for instance be used to get a better picture of the transfer patterns in a given timetable, and thereby making it possible to create better transfer indexes.

General information

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Organisations: Department of Transport, Traffic Modelling

Authors: Schittenhelm, B. (Intern), Landex, A. (Intern)

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Publication date: 2009

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Title of host publication: RailZurich

Main Research Area: Technical/natural sciences

Conference: RailZurich, Zurich, Switzerland, 01/01/2009

Source: orbit

Source-ID: 266527

Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Capacity Measurement with the UIC 406 Capacity Method

This article describes the fast and effective UIC 406 method for calculating capacity consumption on railway lines. It is possible to expound the UIC 406 method in different ways which can lead to different capacity consumptions. Therefore, this article describes how the methodology is expounded in Denmark. This includes how and where to divide the railway lines into line sections, how to analyze stations and junctions, and how to examine line sections with different amounts of tracks.

General information

State: Published

Organisations: Traffic Modelling, Department of Transport, National Rail Authority

Authors: Landex, A. (Intern), Schittenhelm, B. (Intern), Kaas, A. H. (Intern), Schneider-Tilli, J. (Ekstern)

Pages: 55-64

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Editors: Allan, J., Arias, E., Brebbia, C., Goodman, C., Rumsey, A., Sciutto, G., Tomii, N.

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Main Research Area: Technical/natural sciences

Conference: CompRail : Eleventh International Conference on Computer System Design and Operations in the Railway and Other Transit Systems, Toledo, Spain, 01/01/2008

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Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Timetable Attractiveness Parameters

Timetable attractiveness is influenced by a set of key parameters that are described in this article. Regarding the superior structure of the timetable, the trend in Europe goes towards periodic regular interval timetables. Regular departures and focus on optimal transfer possibilities make these timetables attractive. The travel time in the timetable depends on the characteristics of the infrastructure and rolling stock, the heterogeneity of the planned train traffic and the necessary number of transfers on the passenger's journey. Planned interdependencies between trains, such as transfers and heterogeneous traffic, add complexity to the timetable. The risk of spreading initial delays to other trains and parts of the network increases with the level of timetable complexity.

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Authors: Schittenhelm, B. (Intern)

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Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Evaluation of railway capacity

This paper describes the relatively new UIC 406 method for calculating capacity consumption on railway lines. The UIC 406 method is an easy and effective way of calculating the capacity consumption, but it is possible to expound the UIC 406 method in different ways which can lead to different capacity consumptions. This paper describes the UIC 406 method and how it is expounded in Denmark. The paper describes the importance of choosing the right length of the line sections examined and how line sections with multiple track sections are examined. Furthermore, the possibility of using idle capacity to run more trains is examined. The paper presents a method to examine the expected capacity utilization of future timetables. The method is based on the plan of operation instead of the exact (known) timetable. At the end of the paper it is described how it is possible to make capacity statements of a railway network. Some of the aspects which have to be paid attention to making annual capacity statements are presented too.

General information

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Authors: Landex, A. (Intern), Kaas, A. H. (Intern), Schittenhelm, B. (Intern), Schneider-Tilli, J. (Ekstern)

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Main Research Area: Technical/natural sciences

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Publication: Research › Article in proceedings – Annual report year: 2006

Practical use of the UIC 406 capacity leaflet by including timetable tools in the investigations

This paper describes the relatively new UIC 406 method for calculating capacity consumption on railway lines. The UIC 406 method is an easy and effective way of calculating the capacity consumption, but it is possible to expound the UIC 406 method in different ways which can lead to different capacity consumptions. This paper describes how the UIC 406 method is expounded in Denmark. The paper describes the importance of choosing the right length of the line sections examined and how line sections with multiple track sections are examined. Furthermore, the possibility of using idle capacity to run more trains is examined. At the end of the paper a method to examine the expected capacity utilization of future timetables is presented. The method is based on the plan of operation instead of the exact (known) timetable.

General information

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Activities:

1st Summer Course on Railway Timetable Optimization

Bernd Hermann Schittenhelm (Participant)

Department of Transport, Traffic Modelling

Details

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Description

Place: Delft, The Netherlands

Activity: Lecture and oral contribution